PATENT SPECIFICATION 1,057,853

DRAWINGS ATTACHED.

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1,057,853

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COMPLETE SPECIFICATION.

Improvements in or relating to Hearing Aids.

We, A. P. BESSON & PARTNER LIMITED, a British Company, of St. Joseph's Close, Hove 4, Sussex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to hearing aids and in particular to hearing aid components suitable for incorporation in spectacle frames.

Components of the kind stated at present suffer from the drawback that their size has been such that the ear pieces of the spectacle frames housing them have had to be enlarged substantially giving them an undesirable appearance. The present invention provides a microphone and a companion earphone that may be constructed so as to occupy only about two-thirds of the size of previous units of comparable performance and so allow said ear pieces, in which they may be incorporated, to be constructed in a size that is aesthetically acceptable.

In one preferred construction the microphone has a tongue-like armature portion of magnetic material with one end positioned between two small permanent magnets held by a stationary "U" shaped polepiece. The other end of this armature portion is encircled by a stationary electric coil and near the centre of this armature portion is placed a drive pin which extends at right angles to an acoustic diaphragm. These parts are arranged to obtain maximum effectiveness of the magnetic field generated by the magnets. There is very little stray field, and this is further minimised by enclosing the structure in a closely fitting case of ferro-magnetic material, such as nickel steel.

Because each unit is thus magnetically as well as physically enclosed, the troublesome problem of mutual coupling between a microphone and a closely spaced earphone is effectively eliminated.

The drive pin in this microphone unit may be made readily adjustable in mass so that the frequency response of the unit can be varied as desired in the course of production. The drive pin is preferably spring-fitted over the armature to give a secure but pivoting connection to it and the other end of the drive pin is secured to the centre part of the diaphragm. The latter comprises a thin flexible sheet of plastics film, such as Mylar (Registered Trade Mark), cemented along its edges to the rim of the case and having cemented to its centre part a stiffening sheet of thin aluminium.

To facilitate the cementing of this plastics layer onto the casing, the layer is initially made larger than necessary so that it overlaps the top edge of the casing. After this layer has been cemented to the edge, the excess plastics material is trimmed off with a razor blade.

The central and major part of the diaphragm behaves as a rigid piston whose vibration under the excitation of impinging sound waves is transmitted through the drive pin to the armature, the motion of which generates in the coil an electric voltage corresponding to the sound waves.

The stiffening sheet of aluminium on the diaphragm has a raised circular or oval rib which gives added rigidity and which in conjunction with the plastics film beneath

and suitable vent holes serves as a sound transmission tube of considerable length connecting the inside of the case and rear of the diaphragm with the front of the diaphragm and outside. Thus, part of the sound impinging on the front of the diaphragm travels through this tube to the rear side of the diaphragm and, by proper choice of the length of the tube, arrives at the rear in proper phase to reinforce the front sound waves in their action on the diaphragm.

The U-shaped pole-piece of the unit is mounted in relation to the armature so that the various parts can be readily assembled and then given a final adjustment, made quickly and easily from the outside, to extremely precise tolerances (of the order of a few millionths of an inch). This is done with the unit connected in its actual circuit environment and is accomplished without affecting the acoustic sensitivity of the unit. As a result, quantity production of these units is considerably simplified and much tighter quality control achieved in spite of the fact that these units are only about two-thirds of the size of previous ones of comparable quality.

The microphone just described may be made into an earphone simply by modifying the sound transmission tube in the acoustic diaphragm.

In an earphone unit it may be desirable to have its frequency response complement that of a companion microphone. Very fine adjustments in this response can be made by varying the weight of the drive pin as was mentioned and also by changing the mass of the diaphragm. A coarser adjustment may be obtained by mounting the energising magnets in the unit on the end of the armature rather than on the fixed U-shaped pole-piece. Additionally, and this arrangement is particularly suitable for a bone conduction type of unit, the electric coil can also be mounted on the armature.

In order that the invention may be clearly understood reference will now be made to the accompanying drawings, in which:—

Fig. 1 is a perspective view of a spectacle frame having the hearing aid components of the present invention incorporated therein;

Fig. 2 is an enlarged perspective view of a microphone constructed according to the present invention, the casing of the microphone being broken away for purposes of illustration;

Fig. 3 is a side elevation of the microphone with the casing wall removed to illustrate the contents;

Fig. 4 is an end elevation looking in the direction of the arrow A in Fig. 3, the end wall of the microphone casing being partly broken away for purposes of illustration;

Fig. 5 is a detail of the drive pin; and

Fig. 6 is a view similar to Fig. 3 but showing the modifications necessary to construct an earphone.

As shown in Fig. 1 the spectacle frame 1 has a microphone 2 and an earphone 3 mounted in one of its ear pieces 4. Extending downwardly from the earphone 3 is a sound conducting tube 5 whose lower end terminates in a plug 6 adapted to seat within a person's ear. The purpose of Fig. 1 is to illustrate the very small dimensions that may be achieved when microphones and earphones are constructed in the manner disclosed in this specification.

Referring now to Figs. 2 and 3 there is shown, in a greatly enlarged view, a microphone with its casing 7 partly broken away to show the structure inside. This includes an armature having a tongue-like portion 8 extending from the left end of the casing and a base portion 9 extending underneath tongue 8 slightly above the bottom of the casing. The left end of the armature is rigidly supported against the inner vertical end of the casing by a tab 10 welded to the armature at 11 and to the casing at 12. The right end of base 9, (see also Fig. 4) rests upon and is welded to dimples 13 at opposite corners of the casing.

Fastened onto base 9 somewhat to the left of its right end is a U-shaped pole-piece 14 whose legs extend, respectively, above and below the right end of tongue 8. This pole-piece supports the permanent magnets 15 and 16 on opposite sides of the tongue of the armature, the north pole of one magnet facing the south pole of the other, the field generated by the magnets being generally perpendicular to tongue 8. These magnets should have a high permeability. An acceptable material is Alnico V or VI.

The left end of tongue 8 is encircled but not touched by an electric coil 17 which is supported on base 9. The two ends of this coil are connected to terminals 18 and 19 extending through casing 7 and insulated therefrom by an insulator strip 20. Vibration of the tongue in the magnetic field of magnets 15 and 16 generates a corresponding voltage in coil 17, as will be understood by those skilled in the art. The coil 17 signal voltage is then amplified and applied to earphone 3 by conventional amplifier means (not shown) to reproduce the original sound at suitable volume.

Positioned between coil 17 and pole-piece 14 and spring-fitted onto tongue 8 is a drive pin 21 which extends at right angles to an acoustic diaphragm 22. During assembly of these elements, the drive pin is pushed onto the tongue 8 of the armature and grips it, Fig. 4, on opposite sides with a jaw-like spring action. This prevents the drive pin from shifting laterally on the armature but

permits it to pivot slightly. With the drive pin extending upward from the armature as shown, the diaphragm is then placed on the top edge of the casing and cemented to it, the end of the drive pin extending into a hole 23 in the centre of the diaphragm and being joined to it there by a drop of adhesive which hardens when set.

Diaphragm 22 comprises a thin flexible layer 24 of plastics or similarly performing material, such as .00025 inch thick Mylar, whose edges are adhesively secured to casing 7, and a somewhat thicker, stiff layer 25 of metal or the like, such as .002 inch thick aluminium, similarly secured to the layer 24. The side edges of the latter are close to but separated some-what from the top edge of the casing thereby permitting relatively very free vibration of a rigid centre of the diaphragm. The centre part of layer 25 is raised in an oval beading configuration 26 which adds further rigidity to the diaphragm without increasing its weight and which provides a hollow space between metal layer 25 and plastic layer 24. The left end of oval 26 is vented by a front opening 27 through metal layer 25 and the right end is vented by a rear opening 28 through plastics layer 24. Thus a sound transmitting tube comprising two portions of oval 26 in parallel extends between the openings 27, 28. The length of this tube can be varied in production, as desired, by changing the position of openings 27 and 28. To make this tube twice as long, for example, opening 28 can be placed closely adjacent opening 27 with an air seal inside oval 26 in the short length between the openings. Thus, sound will have to travel effectively entirely around oval 26 to go from opening 27 to opening 28. This simple way of adjustment of the length of the sound transmission tube permits considerable adjustment of the frequency response characteristics of the microphone and is a very desirable production aid. The sound transmission tube does not take up valuable space inside casing 7 and it does not complicate fitting or assembly of the parts. It thus represents an important improvement over prior constructions.

The top of the unit is provided with a dished cover 29 which fits snugly onto casing 7 and encloses the diaphragm. The centre of the cover is pierced with an opening 32 which permits sound waves to reach the diaphragm.

Pole-piece 14 and the tongue 8 of the armature provide a generally continuous magnetic loop for the flux produced by magnets 15 and 16. The only air gaps in this circuit are the first one between magnet 15 and the upper side of tongue 8 and the second one between magnet 16 and the lower side of tongue 8, both gaps being relatively short. Now, in order to generate a relatively large voltage in coil 17 for a given up and down movement of tongue 8, which movement may be only a few millionths of an inch, the armature is made of an iron alloy having a very high permeability such as "Mumetal" (Registered Trade Mark). Since this material magnetically saturates easily, it is necessary that tongue 8 be adjusted to an at-rest position between magnets 15 and 16 such that the net steady-state flux through it is as low as possible. However, each time mumetal is bent beyond its elastic limit it loses its desirable magnetic properties, and must be annealed at elevated temperature to regain them. Also, as a practical matter it is impossible during assembly of the unit to position the tongue portion of the armature in exactly the right position between magnets 15 and 16. To permit simple and rapid adjustment of the relative position of tongue 8 while at the same time avoiding the difficulty attendant upon bending mumetal, the portion of the base 9 to the right of pole-piece 14, which constitutes an extension 30, is made accessible from outside the casing through a rectangular window 31, Fig. 4, between dimples 13. Thus, by inserting a suitable tool below or above extension 30, it can be bent up or down thereby vertically moving pole-piece 14 while tongue 8 remains stationary. This provides a very simple and easy way to "centre" the tongue of the armature which, if desired, can be carried out while the microphone is connected in its actual circuit environment. Any direct current which in the circuit would be flowing in coil 17 and which would otherwise cause an unbalanced steady-state flux in the tongue of the armature can thus also be compensated for by this final mechanical adjustment. Since extension 30 is outside the magnetic circuit of the armature, bending it beyond its elastic limit to make this adjustment does not impair the magnetic properties of the armature which, though its base 9 is deflected slightly, is not bent beyond its elastic limit. After the adjustment has been made window 31 is sealed.

Because the reluctance of the magnetic circuit is low, and by virtue of the placement of the armature and pole-piece as shown with magnets on each side of the tongue of the armature, substantially improved efficiency for a given strength of magnet is obtained. This means, conversely, that for a given sensitivity, this unit can be substantially smaller than previous ones. The stray magnetic field in this unit is small to begin with but it is further reduced by casing 7, which is ferro-magnetic, and which is in contact with the sides of armature base 9 and pole-piece 14. Magnets 15

and 16 are made slightly narrower than casing 7 to avoid direct shunting of their field.

The weight of the moving mass can be varied by adjusting the weight of drive pin 21. This is advantageously accomplished, as illustrated in Fig. 5, by fabricating the drive pin of a thin hard layer 33 of a non-magnetic metal such as beryllium copper plated with a thicker layer 34 of a soft, malleable non-magnetic metal such as silver. Then simply by rolling the softer layer to a desired thickness the weight of the drive pin can be adjusted to a very fine degree. By stamping or blanking it out of a larger strip, the edges of the drive pin will shear away with the softer layer 34 bevelled back as indicated at 35 leaving a "knife-edge", formed by the layer 34, adjacent the armature tongue.

Fig. 6 shows an earphone 3 similar in construction to microphone 2. Here, sound waves are produced by the vibration of a diaphragm 36 which is identical with diaphragm 22 except that the diaphragm mass is changed and oval track 26 is generally lengthened; the sound transmission tube formed thereby being adjusted in length to give the desired bass frequency response. The sound waves so produced are conducted through tube 5 to a person's ear. The moving mass of the tongue of the armature in this embodiment is greatly increased by mounting magnets 15 and 16, and if desired coil 17, on the tongue of the armature. To make this a balanced armature type bone conduction receiver, a further distribution of the masses and stiffnesses allow this transducer to efficiently transfer energy to the mastoid bone behind a person's ear.

An actual microphone substantially identical to microphone 2 which has been built and successfully operated had over-all dimensions of $\frac{1}{4}$ by $\frac{1}{2}$ by $\frac{1}{5}$ inch, contained thirteen parts, and had effectively the same sensitivity and response as the smallest known commercially-produced prior unit, which unit contained twenty-three parts and had dimensions of $\frac{3}{8}$ by $\frac{1}{2}$ by $\frac{1}{5}$ inch.

The above particular embodiment described with reference to the drawings is for the purpose of description, the scope of the invention being all such constructions as may fall within the scope of the appended claims.

WHAT WE CLAIM IS:—

1. A hearing aid component comprising a box-like casing containing a U-shaped armature having one arm adjacent one face of the casing and the other arm spaced from and parallel to said face, the web end of said armature being supported by the casing, a coil winding encircling said other arm, a U-shaped pole-piece having one arm affixed to said one arm of said armature such that said other arm of the armature extends between the two arms of the U-shaped pole-piece, a pair of permanent magnets, one in each of the spaces between said other arm of the armature and the U-shaped pole-piece into which said other arm of the armature extends, a drive pin attached to said other arm of the armature, and a diaphragm extending across the casing and attached to said drive pin.

2. A hearing aid component as claimed in claim 1 and wherein said permanent magnets are secured one to each of the arms of the U-shaped pole-piece.

3. A hearing aid component as claimed in claim 1 and wherein said permanent magnets are secured one to each face of said other arm of the armature.

4. A hearing aid component as claimed in any one of claims 1 to 3 and wherein the box-like casing is of ferro-magnetic material.

5. A hearing aid component as claimed in any one of claims 1 to 4 and wherein the arm of the armature that is adjacent one face of the casing extends beyond the U-shaped pole-piece affixed thereon and is fastened at its outer end to said casing, said outer end being bendable from outside said casing to adjust the position of the U-shaped pole-piece relatively to said other arm of said armature.

6. A hearing aid component as claimed in claim 5 and wherein said armature is of an iron alloy which loses its desirable magnetic properties when bent, whereby bending of said extension to position said pole-piece relative to said other arm of said armature does not affect the magnetic properties of the portions of said armature in the alternating signal flux path of the said component.

7. A hearing aid component substantially as hereindescribed with reference to Figs. 2 to 5 of the accompanying drawings.

8. A hearing aid component substantially as hereindescribed with reference to Fig. 6 of the accompanying drawings.

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Reference has been directed in pursuance of Section 9, Subsection (1) of the Patents Act, 1949, to patent No. 869234.

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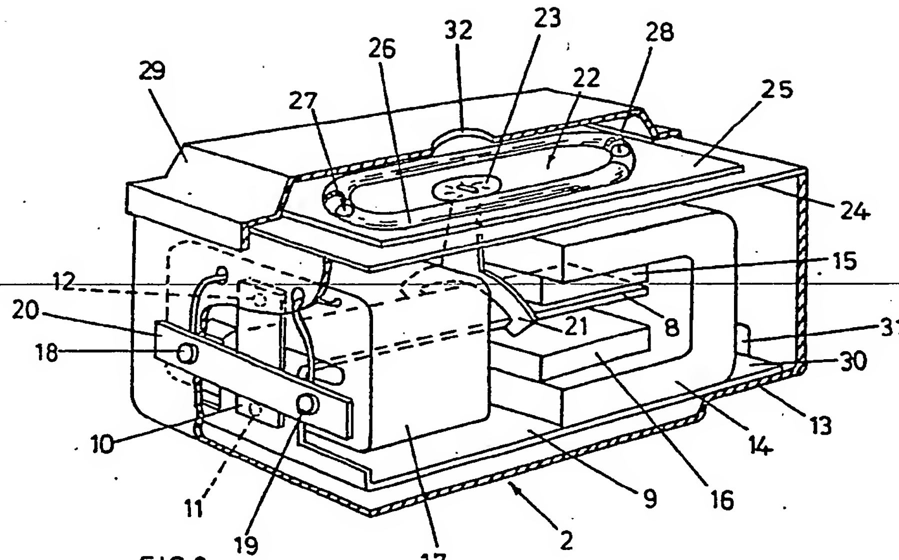
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FIG 2.

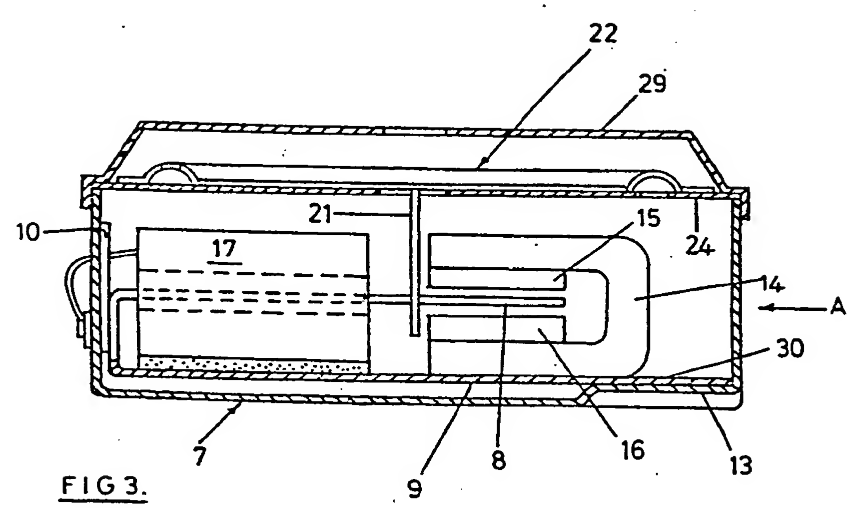
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FIG 3.

1057853 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

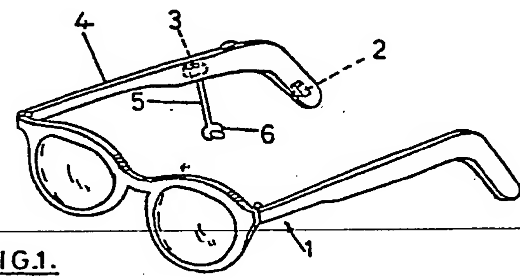

FIG.1.

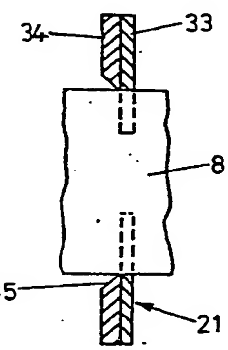

FIG.5.

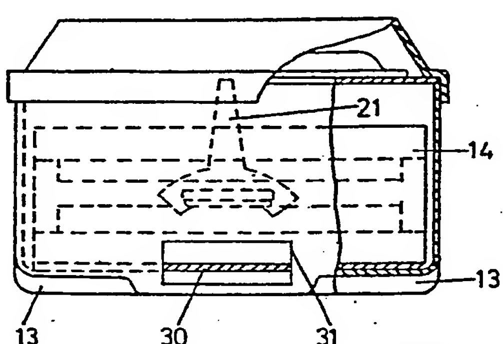

FIG.4.

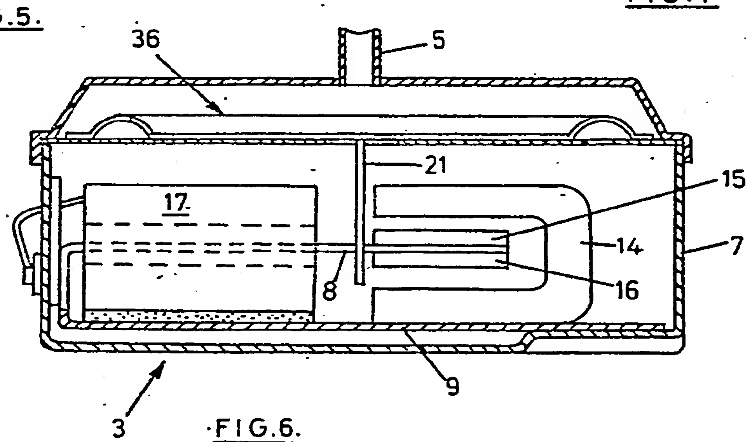

FIG.6.

1057853 2 SHEETS

COMPLETE SPECIFICATION
This drawing is a reproduction of the Original on a reduced scale
Sheets 1 & 2

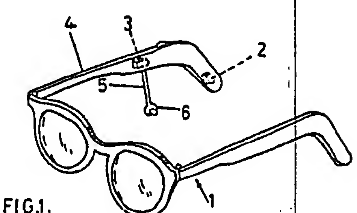

FIG.1.

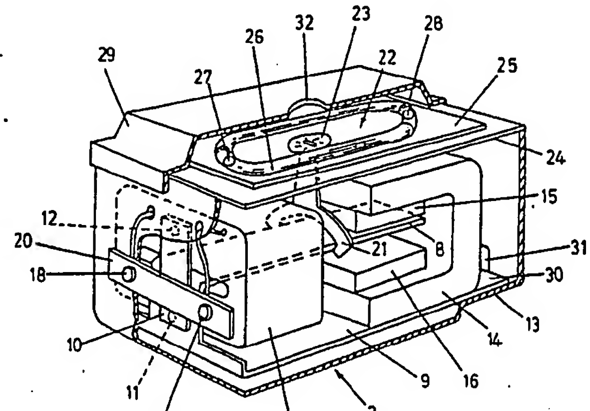

FIG 2.

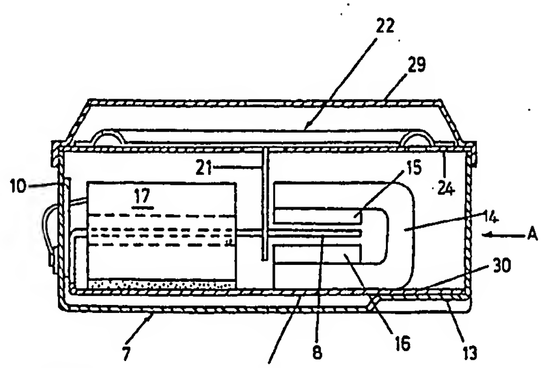

FIG 3.

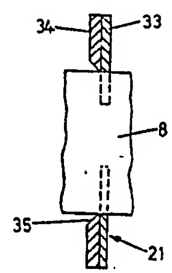

FIG.5.

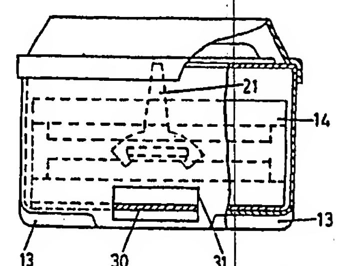

FIG.4.

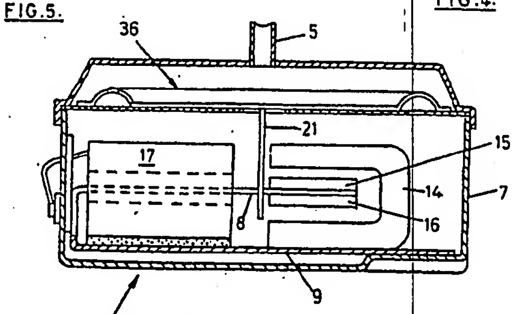

FIG.6.